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Analysis to Support Removal of the Vermont Yankee Toxic Gas Monitoring System

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1.0 INTRODUCTION

This report documents an analysis which supports removal of the Toxic Gas Monitoring System (TGMS) at the Vermont Yankee Nuclear Power Station (VYNPS). The applicable regulatory requirements and the basis for the current TGMS are reviewed. The analysis results demonstrate that the regulatory requirements can be met for VYNPS without the need for a TGMS.

2.0 BACKGROUND

The TGMS is described in VYNPS FSAR Section 7.19. Technical Specification requirements appear in Sections 3.2 and 4.2 of the VYNPS Technical Specifications. The TGMS samples Control Room HVAC intake air for five toxic gases. TGMS trip occurs when monitored gas concentrations reach predetermined setpoints. TGMS trip causes Control Room isolation dampers to close and the Bottled Gas Pressurization System to initiate. These automatic actions are designed to provide Control Room operators with at least two minutes to don breathing apparatus before the Control Room air reaches toxic limits.

The VYNPS TGMS was installed to meet NUREG-0737, Item III.D.3.4 (Reference 1), requirements for Control Room habitability following a postulated off-site chemical release. NUREG-0737, Item III.D.3.4, requires Control Room habitability evaluations for three different hazards:

1. Radiological Release
2. On-Site Chemical Release
3. Off-Site Chemical Release

Vermont Yankee's original evaluation (Reference 2) showed that:

1. For radiological releases, "... no further safeguards are necessary to meet Control Room habitability requirements."

2. "... no potential hazard was defined for Control Room personnel from toxic chemical materials stored on-site."

3. "... the following toxic chemicals shipped via the rail line have been identified as potential hazards to the Control Room personnel":

    - Ammonia
    - Chlorine

- Vinyl Chloride
- Carbon Dioxide
- Methanol

Thus, off-site chemical releases were the only basis for the TGMS at VYNPS.

The NRC Safety Evaluation Report (Reference 3) concluded that upon completion of the modifications to provide a detection system for the five gases listed above, the criteria of NUREG-0737, Item III.D.3.4, would be met. VYNPS installed the TGMS in 1983 and submitted appropriate Technical Specification changes to fulfill the NUREG-0737, Item III.D.3.4, requirements.

Since its installation, the VYNPS TGMS has been an operational burden. Several trouble alarms and spurious trips occur each operating cycle, yet no actual events involving toxic gas concentrations have occurred. These spurious alarms require operator response, hence, are a distraction to Control Room operators. Operators tend to lose confidence in the validity of such alarms, which reduces the effectiveness of the system in a real emergency. As it is, each TGMS unit is unavailable about 10 percent of the time due to preventive maintenance and about 10 percent of the time due to corrective action.

These operational difficulties stem from the fact that it is difficult to maintain instrument calibration within the narrow range required to detect minute quantities of toxic chemicals (e.g., 5 ppm for chlorine). The extent of these difficulties was not anticipated at the time the TGMS was installed. This is evidenced by the fact that the TGMS requires actual calibration every one to two weeks to remain within Technical Specification setpoint limits, yet the Technical Specification calibration frequency is once per operating cycle.

3.0 APPLICABLE REGULATORY CRITERIA

The basis for the VYNPS TGMS is NUREG-0737, Item III.D.3.4, "Control Room Habitability Requirements" (Reference 1). As noted in Section 2.0 above, the TGMS was installed only to meet the 'off-site release" requirements of Reference 1. No plant changes, including this proposed change, have occurred that would impact the conclusions of References 2 and 3 regarding the "radiological release" and "on-site chemical" portions of the Reference 1 requirements. Thus, removal of the TGMS requires only that the off-site chemical hazards be evaluated.

Given that the scope of analysis here involves only off-site chemical release, Reference 1 provides guidance by identifying the appropriate Standard Review Plan (SRP) sections and Regulatory Guides (RG). These are as follows:

RP 2.2.1-2.2.2	"Identification of Potential Hazards in Site Vicinity"
SRP 2.2.3	"Evaluation of Potential Accidents"
SRP 6.4	"Habitability Systems"
RG 1.95	"Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release"
RG 1.78	"Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release"

The guidance provided by these documents is summarized below in the context of this proposed change:

SRP 2.2.1 and 2.2.2, "Identification of Potential Hazards in Site Vicinity"

This document is used to identify potential external hazards. Hazards which are identified as resulting from the presence of hazardous materials or activities in the vicinity of the site are to be reviewed further under SRP 2.2.3. As discussed above, the hazard applicable to this proposed change is the transportation of toxic chemicals near the site.

SRP 2.2.3, "Evaluation of Potential Accidents"

Given a potential hazard identified under SRP 2.2.1 and 2.2.2, SRP 2.2.3 is used to determine which events must be considered further as design basis events. The SRP 2.2.3 acceptance criteria states:

> "The identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant is acceptable if the design basis events include each postulated type of accident for which the expected rate of occurrence of potential exposures in excess of the 10CFR, Part 100, guidelines is estimated to exceed the NRC staff objective of approximately 10^{-7} per year. Because of the difficulty of assigning accurate numerical values to the expected rate of unprecedented potential hazards generally considered in this review plan, judgement must be used as to the acceptability of the overall risk presented.
>
> "The probability of occurrence of the initiating events leading to potential consequences in excess of 10CFR, Part 100, exposure guidelines should be estimated using assumptions that are as representative of the specific site as is practicable. In addition, because of the low probabilities of the events under consideration, data are often not available to permit accurate calculation of probabilities. Accordingly, the expected rate of occurrence of potential exposures in excess of the 10CFR, Part 100, guidelines of approximately 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower."

SRP 2.2.3 goes on to say that if accidents involving the release of chemicals do not meet the above acceptance criteria, an evaluation of the effects of these analyses on Control Room habitability should be made using SRP 6.4, "Habitability Systems."

No SRP 2.2.3 evaluation of the probability of such events was performed in Vermont Yankee's original response to NUREG-0737, Item III.D.3.4. Instead, the deterministic criteria of SRP 6.4 and its supporting regulatory guides (Regulatory Guides 1.78 and 1.95) were used.

SRP 6.4, "Habitability Systems"

The toxic gas portion of SRP 6.4 makes reference to Regulatory Guide 1.78 as the method to be used to determine whether the quantity or location of toxic material is such that additional analysis is necessary. The referenced methods to be used in any additional analyses are Regulatory Guide 1.78 and Regulatory Guide 1.95.

Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release"

Regulatory Guide 1.95 was developed to provide Control Room operator protection from an accidental on-site chlorine release. It uses the methodology of Regulatory Guide 1.78 to calculate the allowable weight of a single chlorine container as a function of distance from the Control Room. Since Vermont Yankee has no on-site storage of chlorine, the Regulatory Guide 1.95 analysis is not applicable.

Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release"

The purpose of Regulatory Guide 1.78 is to identify those chemicals which could result in Control Room uninhabitability. Screening criteria are given in terms of the proximity (within a five-mile radius) and frequency (10 per year for truck and 30 per year for rail) of shipment. A representative list of hazardous chemicals and their toxicity limits is also provided.

For those chemicals that are not eliminated by the proximity/frequency screening criteria, Regulatory Guide 1.78 provides a methodology to calculate Control Room concentration versus time after an accidental release. The acceptance criterion is that the time from detection to the time when the toxicity limit is reached must be at least two minutes to allow operators to don self-contained breathing apparatus.

The analysis of Reference 2 showed that this two-minute criterion was satisfied for all chemicals except five. The TGMS was designed to provide automatic detection and Control Room isolation such that this two-minute criterion could be met for these five chemicals.

4.0 ANALYSIS METHODOLOGY

This report addresses chemical releases from off-site transportation accidents. Both railroad and highway transportation routes are considered. The general methodology applied to each transportation route consists of the following steps. Note that Steps 1 and 2 involve deterministic analyses, and Steps 3 and 4 involve probabilistic analyses. The probabilistic analyses are only performed if the deterministic screening criteria of Steps 1 and 2 are exceeded.

Step 1 - Hazardous Chemical Identification

For the purposes of this analysis, a chemical is identified as hazardous if it meets all of the following criteria:

a. Transportation of a chemical occurs within a five-mile radius of the plant.

b. Shipment frequency is greater than ten per year for truck and 30 per year for rail.

c. Chemical appears on either the Regulatory Guide 1.78 list of potentially hazardous chemicals or the Environmental Protection Agency's (EPA's) list of Extremely Hazardous Substances (Reference 6).

Step 2 - Control Room Concentrations

For each chemical identified as hazardous in Step 1, a calculation of Control Room concentration versus time is performed. The accident is assumed to occur at the transportation route's closest proximity to the plant. No credit is taken for the TGMS. These calculations were performed using the HAZARD computer code (References 7 and 8), following the guidance of Regulatory Guide 1.78. The HAZARD code accounts for such parameters as chemical volatility, atmospheric dispersion, and Control Room intake/exhaust flow.

The toxicity limits used in these calculations are based on the "Immediately Dangerous to Life and Health" (IDLH) concentrations published by the National Institute of Occupational Safety and Health (NIOSH) (Reference 9). IDLH values have been developed with acute human toxicity as the principal consideration. The IDLH provides the basis from which the EPA developed levels of concern when emergency planning for EHS releases (Reference 6).

Chemicals are judged not to require an automatic detection system if either:

a. Control Room concentrations never reach toxic limits, or

b. There is at least two minutes between the time that the toxic gas is detectable by smell by the operating crew and the time that the toxic limit is reached.

Step 3 - Probability of Control Room Uninhabitability

Chemicals which can reach toxic levels faster than two minutes after detection are identified in Step 2. These chemicals require an automatic detection system to satisfy the deterministic criteria of Regulatory Guide 1.78. However, the deterministic criteria of Regulatory Guide 1.78 are only required for potential hazards whose frequency of causing a radiological release in excess of 10CFR100 limits exceeds the SRP 2.2.3 guideline of 1E-7 to 1E-6 per year. For these chemicals, the annual probability of Control Room uninhabitability is calculated using the following information:

R = Annual accident rate per mile.

R_C = Conditional probability of a significant chemical release, given an accident.

N = Annual number of shipments within a five-mile radius of the plant.

L = Length, in miles, of transportation route within a five-mile radius of the plant.

F = Annual frequency of wind speeds and stability classes that could disperse plume to plant.

A potential accident involving release of a chemical is judged to meet the SRP 2.2.3 criteria if the frequency of Control Room uninhabitability is less than the SRP 2.2.3 lower bound of 1E-7 per year.

Step 4 - Frequency of Significant Radiological Release

The SRP 2.2.3 guideline of 1E-7 to 1E-6 actually refers to the frequency of a 10CFR100 fission product release involving significant core damage. In order to cause such a release, the Control Room uninhabitability must lead to a plant trip with operating crew and equipment failure leading to failure of a critical safety function such as core cooling or decay heat removal. Step 4 calculates the frequency of a 10CFR100 fission product release resulting from an off-site chemical release.

5.0 HIGHWAY ANALYSIS RESULTS

The highway analysis involves Steps 1 and 2 from Section 4.0, "Analysis Methodology." Sections 5.1 and 5.2 below demonstrate that Regulatory Guide 1.78 requirements are met. Accordingly, Steps 3 and 4 were not necessary.

5.1 Hazardous Chemical Identification

Contacts were made with both state government agencies and chemical distributors (Reference 12) to identify the types and quantities of chemicals transported past Vermont Yankee on U.S. Route 91, the most frequently traveled major highway (see Figure 5-1).

The chemicals identified during the survey were compared to Regulatory Guide 1.78 and EPA's list of Extremely Hazardous Substances (EHS) (Reference 6). EHSs are those chemicals that, because of extreme toxicity, are most likely to cause severe toxic effects in humans who are exposed to them due to an accidental release. Chemicals appearing on either list were considered for further evaluation.

From the list of chemicals identified, the following were considered potential "toxic" hazards:

- Chlorine
- Anhydrous Ammonia
- Sulfur Dioxide
- Sulfuric Acid
- Propane (LPG)

5.2 Control Room Concentrations

Loss of Control Room habitability occurs when the Control Room concentration of a hazardous chemical exceeds its "toxic limits" in less than two minutes after detection. The toxic limit in this analysis is considered to be the National Institute of Occupational Safety and Health (NIOSH) "Immediately Dangerous to Life and Health (IDLH)" concentration (Reference 9). This value is the maximum concentration from which an operator could escape within 30 minutes without experiencing any escape-impairing or irreversible health effects.

To calculate Control Room concentration, the computer program HAZARD was used (References 7 and 8). Control Room habitability is maintained if Control Room concentrations never equal or exceed the IDLH value, or if there is at least two minutes between the time the toxic gas is detectable by smell by the operator and the time that the IDLH value is reached. Two minutes is considered sufficient time for a trained operator to put a self-contained breathing apparatus into operation (Reference 11).

The results (from Reference 12) are shown in Table 5.1. Also listed is the quantity of the largest container shipped and the IDLH value.

As shown, the maximum Control Room concentration for each chemical is less than its corresponding IDLH value. The "toxic limit," therefore, is not reached, and Control Room habitability will be maintained in the event of a postulated highway accident.

TABLE 5.1

Control Room Concentrations of Hazardous Chemicals from Highway Accidents

Chemical	Quantity	Maximum Control Room Concentration	IDLH
Chlorine	1 ton	23 ppm	30 ppm
Ammonia	16 tons	258 ppm	500 ppm
Sulfur Dioxide	1 ton	15 ppm	100 ppm
Sulfuric Acid	6,500 gal	<1 ppm	20 ppm
Propane	10,000 gal	1,491 ppm	20,000 ppm

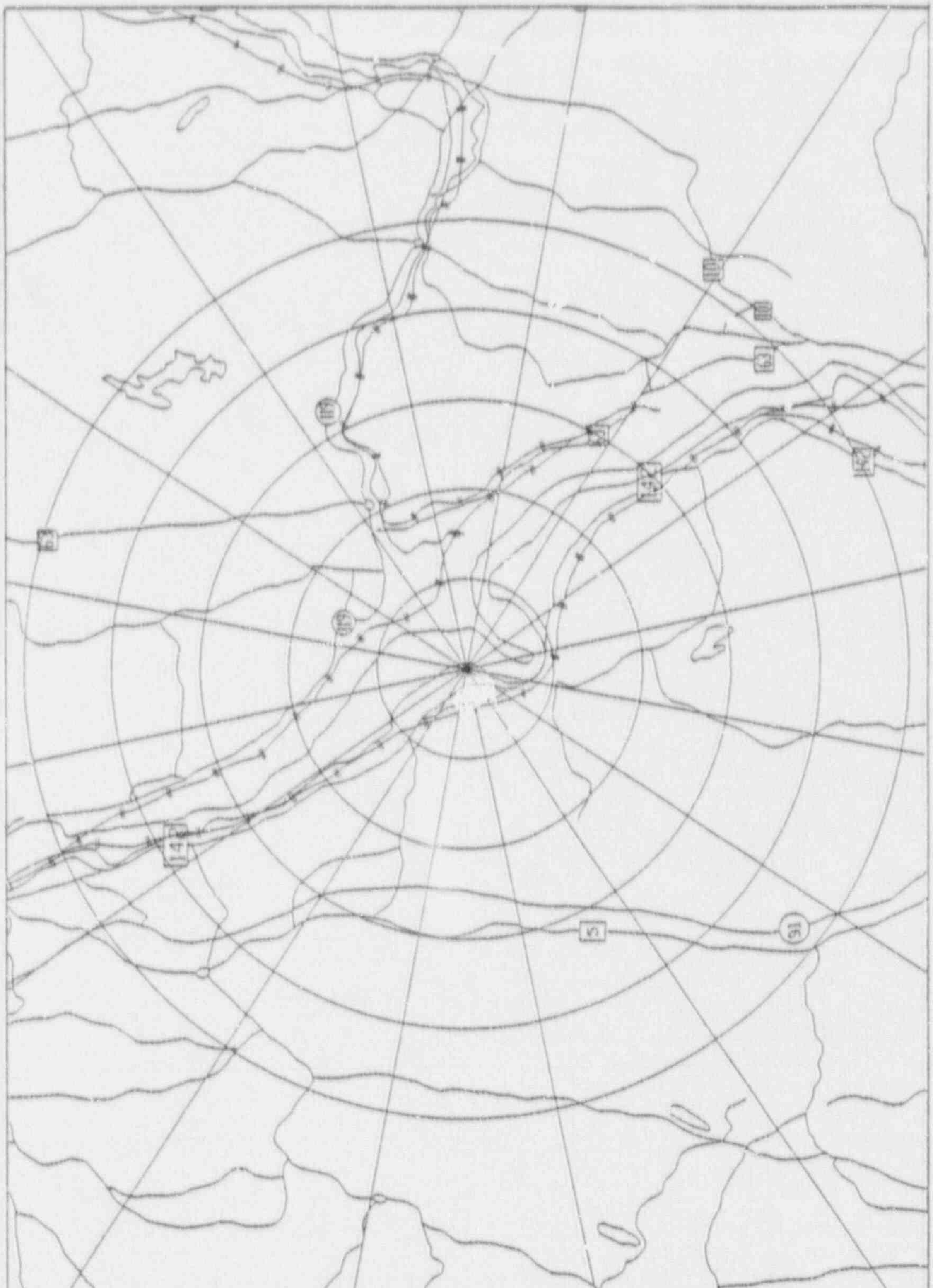

FIGURE 5-1 General Site Area Within Five Miles

6.0 RAILROAD ANALYSIS RESULTS

The railroad analysis involves Steps 1 through 4 from Section 4.0, "Analysis Methodology." Sections 6.1 and 6.2 below show that, of the hazardous chemicals identified, only chlorine exceeds Regulatory Guide 1.78 criteria. Therefore, probabilistic analyses (Sections 6.3 and 6.4 below) were performed for chlorine.

6.1 Hazardous Chemical Identification

Two railroads operate along the tracks adjacent to Vermont Yankee: Central Vermont Railroad and Springfield Terminal Railway Company (formerly Boston and Maine Railroad). Each was contacted and asked to provide a list of hazardous chemicals transported (Reference 13). The railroad tracks opposite Vermont Yankee across the river are no longer in service (Reference 14).

As in Section 5.1, the chemicals listed were compared to Regulatory Guide 1.78 and EPA's list of EHS (Reference 6). Chemicals appearing on either list were considered for further evaluation.

The chemicals considered toxic are listed in Table 6.1. However, only chlorine, propane, nitrogen, and carbon dioxide were evaluated because they exceed 30 shipments per year.

6.2 Control Room Concentrations

As in Section 5.2, the computer code HAZARD (References 7 and 8) was used to calculate Control Room concentrations. Control Room habitability is maintained if Control Room concentrations never equal or exceed the IDLH value, or if there is at least two minutes between the time the toxic gas is detectable by smell by the operators and the time that the IDLH value is reached.

For chemicals that act only as asphyxiants (e.g., nitrogen), Control Room habitability is lost if the oxygen content drops below 18 percent (Reference 15). It is assumed the chemicals will not be detected prior to reaching the asphyxiation level, thus the two-minute warning criterion is not used. Percent oxygen content is calculated as $O_2\% = 20.9\ (\frac{100 - X}{100})$, where X is the percent by volume of the hazardous chemical.

The results (from Reference 13) are listed in Table 6.2. The IDLH value, detection threshold, and the time from detection to IDLH are also listed where applicable.

As shown, the maximum Control Room carbon dioxide concentration is below the IDLH value. The nitrogen concentration (31,127 ppm) is equivalent to 3.1 percent by volume. This value would reduce the Control Room oxygen content to 20.25 percent, which is well above the recommended minimum of 18 percent (Reference 15).

The maximum Control Room concentrations of both propane and chlorine are above their respective IDLH values. However, propane meets the regulatory guide of more than two minutes between the time the gas is detected and the time the IDLH value is reached. The time difference for chlorine, however, is only about one minute.

Carbon dioxide, nitrogen, and propane meet Regulatory Guide 1.78 criteria to maintain Control Room habitability. This is not the case for chlorine. Accordingly, chlorine was evaluated further to determine the probability of Control Room uninhabitability.

6.3 Probability of Control Room Uninhabitability

A hazard model was used to calculate the annual probability (P) of Control Room uninhabitability in the general form:

$$P = (R) \times (R_c) \times (N) \times (L) \times (F)$$

where:

R = Annual train accident rate per mile.

R_c = Conditional probability that a significant chemical release will occur, given an accident.

N = Annual number of shipments within five-mile radius of plant.

L = Length, in miles, of railroad track within five-mile radius of plant.

F = Annual frequency of wind speeds and stability classes that could disperse plume to plant.

The probability of loss of Control Room habitability, given a release, varies as a function of distance from the Control Room air intake, wind direction, speed, and atmospheric stability. To account for these variables, the analysis was performed over 17 discrete segments along the railroad track and the probability summed for each segment. (See Figure 6-1)

The probability of loss of Control Room habitability was calculated by assuming that the midpoint of each segment represents the average distance for the segment of track being analyzed. The total probability, P, therefore, becomes the sum of the probabilities associated with each segment:

$$P = \sum_{i=1}^{n} [(R_i) \times (N_i) \times (L_i) \times (R_{c_i}) \times (F_i)], \text{ where } n = 17$$

The parameters R_i and N_i are constants and do not vary between segments. The parameters R_{c_i}, L_i, and F_i, on the other hand, vary from segment to segment. The general form of the hazard model, hence, becomes:

$$P = R \times N \times \sum_{i=1}^{n} [(L_i) \times (R_{c_i}) \times (F_i)]$$

(R) Railcar Accident - There is no published accident rate for chlorine. Instead, the average accident rate for railroads, in general, during the five-year period from 1984 to 1988 was used (Reference 16).

This annual average is 5.40×10^{-6} accident/mile.

(N) Annual Number of Shipments - From Table 6.1, the annual number of chlorine cars transited is 60.

(L_i) Segment Lengths of Railroad Track in Miles That Chlorine Would Transit Within Five Miles of Plant - From Figure 6-1, which shows the railroad and the general site area, the total length of track was measured to be 10.7 miles. Segment lengths (L_i) are listed in Table 6.3.

(R_{c_i}) Conditional Probability of Significant Chlorine Release - Given an accident, there must be a release to affect the plant. In addition, given a release, it must be significant to be of concern. Therefore, R_{c_i} is the product of the probability of a release given an accident and the probability of a significant release given a release; $R_{c_i} = R_{r_i} \times R_{s_i}$.

The probability of a release given an accident, R_{r_i}, was estimated from the accident data involving all hazardous materials, chlorine being a hazardous material (Reference 16).

The average rate for the five-year period, from 1984 to 1988, is 0.124 releases/accident, which is assumed constant for each segment.

The probability of a significant release given a release, R_{s_i}, was determined from actual chlorine incident data (Reference 17). During the years 1971 through 1989, there were 64 chlorine railcar incidents that involved a release. Of these, the largest was 17,440 gallons, and the smallest was one gallon. However, to be significant, the release must be of sufficient volume to produce toxic limits inside the Control Room.

To determine the minimum volume needed to produce toxic levels within the Control Room for each of the 17 segments, the program HAZARD (References 7 and 8) was used. The probability of a significant release given a release, R_{s_i}, for each segment is simply the number of releases in the data base that were greater than or equal to the minimum volume for each segment divided by 64, the total number of releases in the data base. The results are shown in Table 6.3.

(F_i) <u>Probability of Wind and Stability Classes That Could Disperse Plume to Plant</u> - Adverse meteorological conditions include both the likelihood of the stability class occurring and the likelihood of the wind blowing toward the Control Room intake.

To account for the many wind sectors along the railroad track, the midpoint at each segment was analyzed (using HAZARD) to determine what stability classes and wind speeds produced toxic limits inside the Control Room given a worst-case accident. In other words, an analysis was performed for each segment over the seven stability classes and the five wind speed categories to determine which conditions resulted in the loss of Control Room habitability.

The toxic limit conditions were then compared to a site meteorological joint frequency analysis (Reference 20) to calculate the annual frequency (F_i) that toxic limits can be expected in the Control Room for each segment.

Combining the segment analysis input parameters (see Table 6.3), the annual probability of chlorine reaching toxic levels in the Control Room is as follows:

$$P = 5.40 \times 10^{-6} \times 60 \times 0.124 \times \sum_{i=1}^{17} [R_{s_i} \times L_i \times F_i]$$

$$P = 4.39 \times 10^{-7} \text{ per year}$$

6.4 Frequency of Significant Radiological Release

Sections 6.1 and 6.2 show that an off-site chlorine release is the only event which does not satisfy the deterministic criteria of Regulatory Guide 1.78. SRP 2.2.3 requires that such an accident be considered as a design basis event only if the frequency of exceeding 10CFR100 guidelines for fission product release exceeds 1E-7 per year (a value of 1E-6 per year is acceptable when combined with reasonable qualitative arguments that the realistic probability is lower).

A 10CFR100 fission product release is a result of significant core damage. Thus, this section estimates the core damage frequency due to an off-site chlorine release and compares this to the SRP 2.2.3 acceptance guidelines.

6.4.1 Initiating Event

The initiating event considered here is an off-site transportation accident which leads to toxic chlorine concentrations in the Control Room within two minutes after operator detection. As calculated in Section 6.3, the frequency of this initiating event is 4.39×10^{-7} per year.

This initiating event does not lead directly to core damage. For core damage to occur, a plant trip must occur, and there must be failure of a critical safety function, e.g., the core injection or containment heat removal function must fail.

6.4.2 Plant Trip Occurs

Since chlorine is not hallucinogenic, it is assumed that the operators, even if incapacitated, will not act in such a way as to deliberately place the plant in an unsafe state. Rather, they simply will not be able to respond positively if required to do so. This means that they will not be able to respond to events set in motion by a transient. For Vermont Yankee, it is conservatively estimated that there are an average of six transients per year that result in reactor scram and demand for a safe shutdown. In addition, it is estimated that operators take action to prevent such occurrences an additional ten times per year (Reference 18). Assuming that the operating crew is incapacitated for an average of four hours*, the probability that a shutdown challenge occurs during this four-hour period is calculated as:

$$X = 4 \text{ hours} \times \frac{16 \text{ challenges/year}}{8{,}760 \text{ hours/year}} = .0073$$

Even if the operators are unable to respond to a transient challenge, core melt and the release of radioactive material to the environment do not follow directly. The possibility that the plant can remain in a safe, stable state given a scram challenge is estimated below, based on an evaluation of the core coolant injection and containment heat removal critical safety functions.

6.4.3 Coolant Injection Fails

The emergency core cooling systems at Vermont Yankee are automatically initiated without the need for operator action. The emergency core cooling

* This time was chosen because the accident will occur, on the average, halfway through a typical operating crew shift of eight hours.

function can be satisfied by either the High Pressure Coolant Injection (HPCI) System or the Reactor Core Isolation Cooling (RCIC) System. The emergency core cooling function can also be satisfied by either the Low Pressure Coolant Injection (LPCI) System or the Low Pressure Core Spray (LPCS) System after successful operation of the Automatic Depressurization System (ADS).

Thus, the failure probability of the core injection function can be approximated by the following equation:

Core Injection Failure = [HPCI x RCIC] x [ADS + (LPCI x LPCS)]

Where:

HPCI = Probability of HPCI System Failure
RCIC = Probability of RCIC System Failure
ADS = Probability of ADS System Failure
LPCI = Probability of LPCI System Failure
LPCS = Probability of LPCS System Failure

The probability of High Pressure Injection System failure [HPCI x RCIC] is conservatively estimated to be 1.0 (guaranteed failure).

The Automatic Depressurization System is initiated on either of the following accident signals:

- Low-low reactor water level sustained for eight minutes.
- High drywell pressure and low-low reactor water level.

The 120-second ADS timer is initiated if either of the signals is present. The ADS valves will automatically open to relieve pressure if the water level has not been restored and if any of the low pressure ECCS pumps are running.

The ADS initiation causes the RPV to depressurize rapidly. The failure probability for automatic depressurization is taken from previous PRAs (References 18 and 19) with the failure probabilities for operator initiation and external nitrogen supply both set to 1.0. This results in a failure probability over four hours of 1E-3 for the failure to depressurize. This system is highly reliable because it is a redundant safety system designed to actuate automatically under these conditions. The TMI modification to ADS which results in depressurization on low level only contributes to the low assessed failure probability. Low pressure systems will reliably inject following depressurization because of the automatic design of the low pressure system response.

The failure probability of the multiple Low Pressure Injection Systems (two LPCI and two Core Spray) can be estimated by comparison with other similar plants and their PRAs. The failure probabilities are as follows:

Combined Conditional Failure Probability Over 24 Hours for LPCI and Core Spray	Reference
7.7E-5	Limerick PRA (Reference 18)
6.25E-4	Shoreham PRA (Reference 19)

The Limerick design has individual reactor pressure vessel nozzle injections for LPCI which is different from Vermont Yankee's configuration. The Shoreham configuration is similar to Vermont Yankee's and, therefore, it is used as the basis, and a factor of three increase is used to conservatively cover differences in the two systems. Therefore, the failure probability of the low pressure ECCS is conservatively taken to be 1.8E-3 for the purposes of the evaluation of a four-hour mission time. This leads to a total conditional failure probability of adequate low pressure injection [ADS + (LPCI x LPCS)] of 2.8E-3 over a four-hour mission time without operator intervention.

Thus, the combined probability of coolant injection failure is estimated to be 2.8E-3.

6.4.4 Containment Heat Removal Failure

Even if the coolant injection function is successful, core cooling systems can be jeopardized if the Main Steam Isolation Valves (MSIVs) are closed, and if the containment heat removal function fails. We assume (conservatively) that the MSIVs close when the reactor trips. The probability of the containment heat removal function is estimated from past PRA evaluations (References 18 and 19). The estimate for RHR unavailability without operator recovery actions is 4E-4. This is dominated by hardware failures which, for this analysis, are assumed unrecoverable despite having approximately 20 to 30 additional hours for repair.

Because adverse impacts on operating crew actions to align containment heat removal systems may be anticipated due to residual effects of the toxic gas outside of the Control Room, only RHR alignment from the Control Room is assumed possible. No recovery or repair actions are assumed possible, and the probability of failure of the containment heat removal function is estimated to be 4E-4.

6.4.5 Frequency of Core Damage

Based on the above, the core damage frequency from this initiating event is estimated as follows:

Core Damage Frequency = initiating event frequency x

probability of plant trip x

(probability of core injection failure + probability of containment heat removal failure)

= 4.39E-7 x 7.3E-3 x (2.8E-3 + 4E-4)

= 1E-11 per year

This result shows that the estimated core damage frequency due to an off-site chlorine release is far below the SRP 2.2.3 guidelines. Thus, this event does not require consideration as a design basis event, and the Regulatory Guide 1.78 provisions for an automatic detection system are not required.

6.5 Treatment of Uncertainties

The probabilistic analyses of Sections 6.3 and 6.4 are based on point-estimate values. The point-estimates used in this analysis are based on the best available data and engineering judgement. These values were chosen to be "as representative of the specific site as is practicable," as specified in the SRP 2.2.3 guidance.

SRP 2.2.3 recognizes the "difficulty of assigning accurate numerical values to the expected rate of unprecedented potential hazards," and that judgement must be used as to the acceptability of the overall risk presented. The analysis results presented in Section 6.4 show that there are large margins to SRP 2.2.3 guidelines. These margins constitute the "reasonable qualitative arguments" referred to in SRP 2.2.3 that the "realistic probability can be shown to be lower" than the SRP 2.2.3 guidelines.

Thus, the use of best-estimate values and the large margins in the results satisfy the SRP 2.2.3 guidelines for use of site-specific estimates and reasonable judgements in evaluating the risk.

TABLE 6.1

List of Hazardous Chemicals Transported by Railroad

Chemical (1)	Central Vermont (2)	Springfield Track (2)	Total Per Year
Carbon Dioxide	395	96	491
Nitrogen	248	----	248
Propane (LPG)	60	162	222
Chlorine	60	----	60
Sulfuric Acid	----	24	24
Anhydrous Ammonia	1	6	7
Methyl Alcohol	----	4	4
Xylene	----	2	2

Notes: (1) Listed in either Regulatory Guide 1.78 or EPA's Extremely Hazardous Substance List.

(2) Railcars per year.

TABLE 6.2

Control Room Concentrations of Hazardous Chemicals from Railroad Accidents

		Carbon Dioxide	Nitrogen	Propane	Chlorine
1.	Quantity	20,000 gal	30,000 gal	33,500 gal	20,000 gal
2.	Detection* Threshold	N/A	N/A	0.5 ppm	0.2 ppm
3.	IDLH**	50,000 ppm	N/A	20,000 ppm	30 ppm
4.	Control Room Maximum	20,631 ppm	31,127 ppm	28,039 ppm	17,376 ppm
5.	Time (IDLH-Detect)	N/A	N/A	>2 min	<2 min

*References 21 and 22
**Reference 9

TABLE 6.3

Summary of Lost Control Room Habitability

Segment	(1) Annual Accident Rate (R)	(2) Number Railcars (N)	(3) Release Probability	(4) Cl_2 Release Probability (R_{s_i})	(5) Segment Length (L_i)	(6) Wind/Stability Frequency (F_i)	(7) Annual Probability (P) 1x2x3x4x5x6
A	5.40E-06	6.00E+01	1.24E-01	1.56E-02	1.02E+00	0.00E+00	0.00E+00
B	5.40E-06	6.00E+01	1.24E-01	1.56E-02	1.08E+00	1.44E-03	9.75E-10
C	5.40E-06	6.00E+01	1.24E-01	1.56E-02	1.00E+00	6.11E-03	3.83E-09
D	5.40E-06	6.00E+01	1.24E-01	1.56E-02	9.50E-01	4.70E-02	2.80E-08
E	5.40E-06	6.00E+01	1.24E-01	3.13E-02	3.20E-01	7.13E-02	2.86E-08
F	5.40E-06	6.00E+01	1.24E-01	1.09E-01	3.00E-01	9.30E-02	1.22E-07
G	5.40E-06	6.00E+01	1.24E-01	1.25E-01	1.90E-01	7.25E-02	6.92E-08
H	5.40E-06	6.00E+01	1.24E-01	1.25E-01	1.70E-01	5.48E-02	4.68E-08
I	5.40E-06	6.00E+01	1.24E-01	1.25E-01	2.20E-01	6.57E-02	7.26E-08
J	5.40E-06	6.00E+01	1.24E-01	3.13E-02	5.00E-01	3.30E-02	2.07E-08
K	5.40E-06	6.00E+01	1.24E-01	3.13E-02	5.50E-01	5.10E-02	3.53E-08
L	5.40E-06	6.00E+01	1.24E-01	1.56E-02	7.50E-01	2.29E-02	1.08E-08
M	5.40E-06	6.00E+01	1.24E-01	1.56E-02	3.50E-01	5.99E-04	1.32E-10
N	5.40E-06	6.00E+01	1.24E-01	1.56E-02	1.05E+00	4.79E-04	3.16E-10
O	5.40E-06	6.00E+01	1.24E-01	1.56E-02	1.00E+00	1.20E-04	7.52E-11
P	5.40E-06	6.00E+01	1.24E-01	1.56E-02	9.50E-01	1.20E-04	7.15E-11
Q	5.40E-06	6.00E+01	1.24E-01	1.56E-02	3.00E-01	0.00E+00	0.00E+00
						TOTAL	4.39E-07

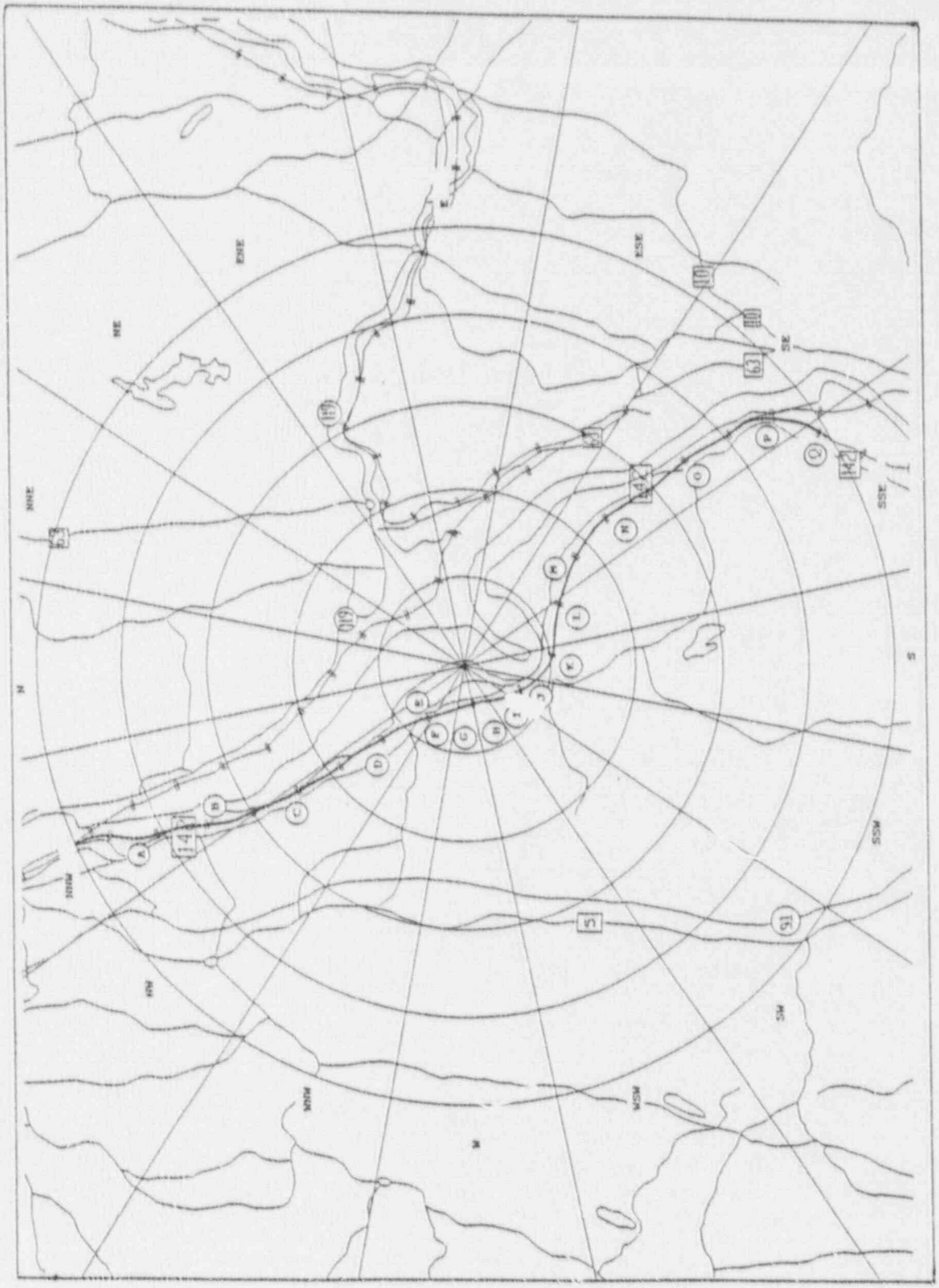

FIGURE 6-1 Discrete Segments Along Railroad Track

7.0 CONCLUSIONS

The analysis considered in this report evaluates Control Room habitability in order to address NUREG-0737, Item III.D.3.4, requirements for off-site toxic chemical releases. The evaluation includes both deterministic and probabilistic analyses, and takes no credit for the existing TGMS. The deterministic analyses show that the Regulatory Guide 1.78 guidelines are met for all chemicals except chlorine. The combined probabilistic analyses show that the probability of a 10CFR100 release due to an off-site chlorine release is far below the SRP 2.2.3 guideline for consideration as a design basis event.

Together these analyses show that the TGMS is not required to meet the regulatory criteria specified in NUREG-0737, Item III.D.3.4. Since NUREG-0737, Item III.D.3.4, is the basis for the TGMS, this analysis justifies removal of the TGMS at VYNPS.

8.0 REFERENCES

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4. Vermont Yankee Nuclear Power Station Final Safety Analysis Report.

5. Vermont Yankee Nuclear Power Station Technical Specifications.

6. "Technical Guidance for Hazard Analysis, Emergency Planning for Extremely Hazardous Substances," U.S. Environmental Protection Agency, Federal Emergency Management Agency, U.S. Department of Transportation, December 1987.

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10. NUREG-75/087, "Standard Review Plan," Sections 2.2.1, 2.2.2, 2.2.3, and 6.4.

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12. YAEC Engineering Calculation, VYC-912, "Highway Hazardous Materials Accident Analysis," 1990.

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20. YAEC Engineering Calculation, VYC-916, "VY Lower Level Joint Frequency Wind Analysis," 1990.

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